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Dandelander Mission Concept

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Mission Goals and Objectives

- Mission goal is to simultaneously reduce cost/risk of deep space science missions
    - Qualify low cost technologies for deep space missions
    - Demonstrate, in flight, specific, new, enabling technologies
- Mission objectives of proposed mission concept
    - Demonstrate that modern small satellite technology can be leveraged for deep space applications
    - Qualify new, simple EDL process to enable deployment of multiple, low cost small planetary landers
    - Examine alternative risk/benefit approach to deep space missions, predicated on use of multiple low cost systems not all of which need to survive for complete mission success
    - Acquire high-value science using low cost technologies

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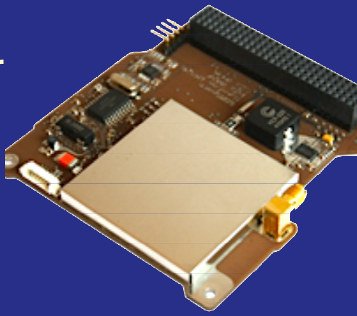
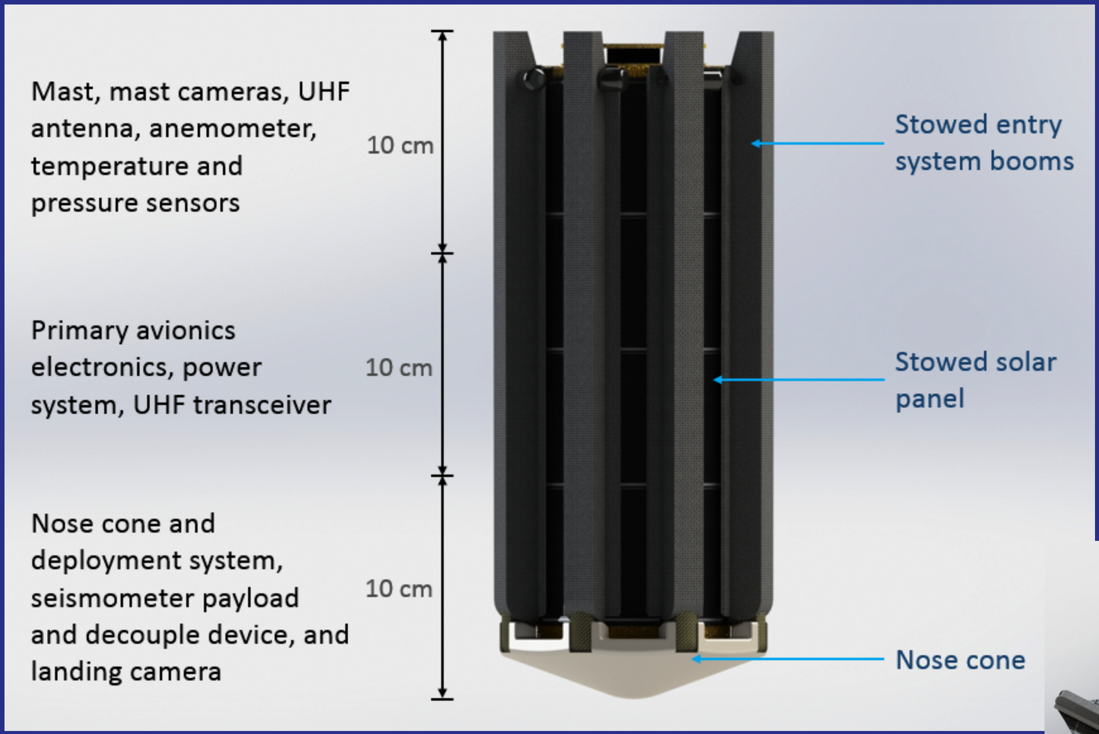
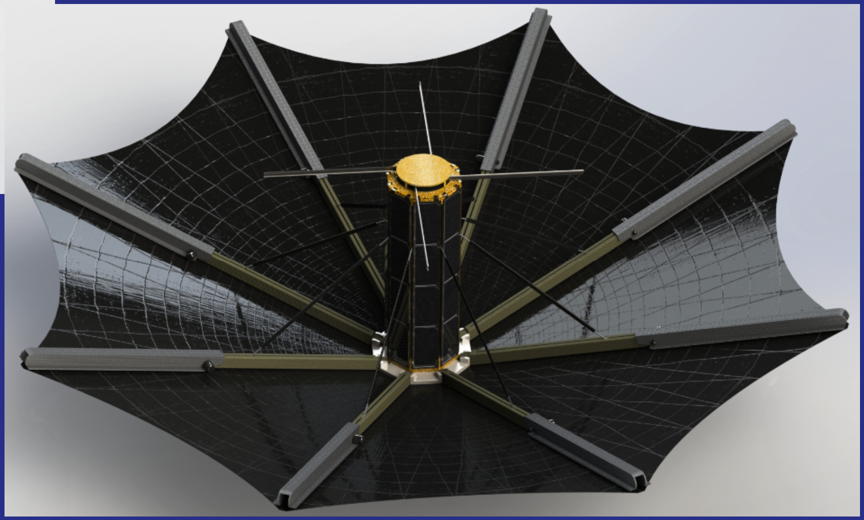
Right Risk / Reward Opportunity

- Affordable!
- nanoADEPT — also designated as “1-m ADEPT”
  - Low-cost Mars EDL system to deliver scientifically useful payload
  - Based on ADEPT (Adaptable Deployment Entry and Placement Technology)
  - Customized for Mars entry
  - Mechanically deployable hypersonic decelerator
  - Low areal mass carbon fabric and rib structure
  - No propulsion system and no parachute
- Proximity-1 Micro-Transceiver
  - Bootstraps AstroDev development of Lithium UHF transceiver
  - Operates at up to 4 W RF (PAE~35%), 70 g, 10 x 5 x 1 cm
- Geophone-based Seismometer



Stowed and Deployed Entry System





Entry system:

- Cone angle of 70°
- 60+ cm diameter

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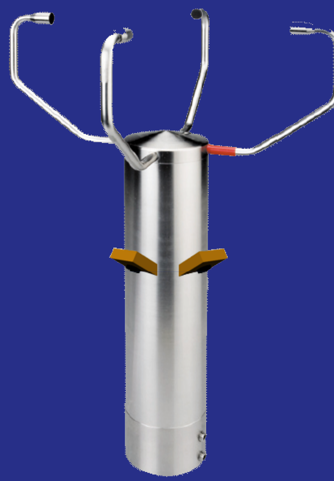
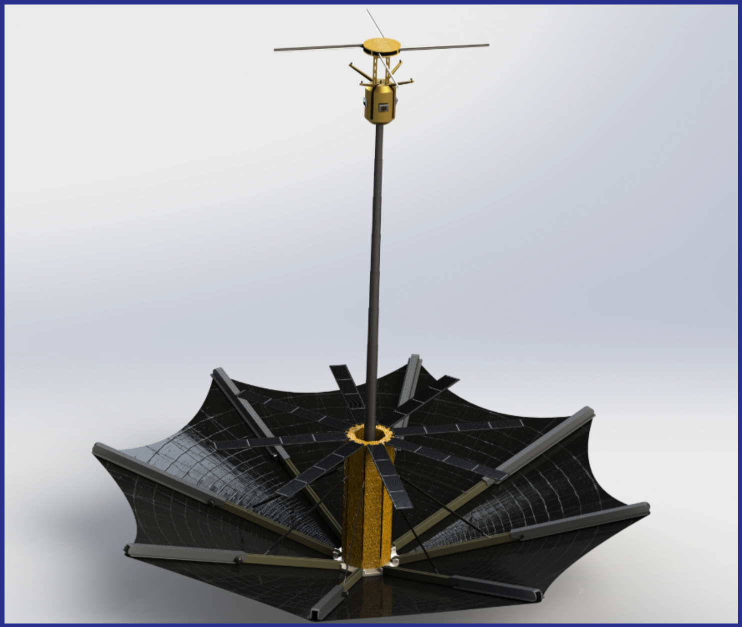
Surface Science Payload

Instrument	*Description*
Seismometer	***Geophone: 1-1000 Hz*** ***Isolated from structure***
Anemometer	***Ultrasonic, 3 axis*** ***0-75 m/sec ± 2%, 0-360° ± 1°***
Pressure	***Barocap 1-1150 ± 3 Pa***
Temperature	***150-300 ± 0.1 K***
Cameras ***(12 Mpixel)***	***Four horizontal*** ***One solar/sky 90°x70°*** ***One descent 90°x70°***

- Geophone measures ground velocity rather the its derivative (acceleration)
- Detection limit at ~ -144 dB (at 1000 km, 1E14 Nm source moment, 6 dB detection limit and 1 Hz rate)



- Mast extends to ~1 m above surface



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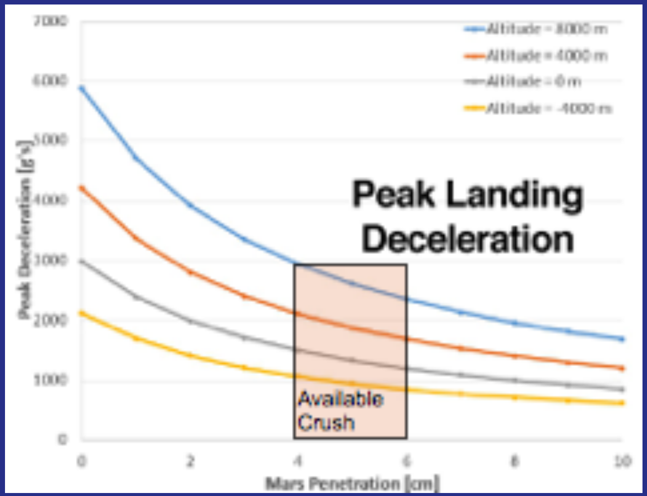
Entry and Landing Parameters

- Dynamically stable through all aerodynamic regimes
  - Including transonic (to be tested)
- Acceptable terminal velocity
- Worts-case impact shock estimated for ground cover area assumptions (bedrock/cobbles/boulders ~20%)
- System can land successfully on ~80% of Mars surface at average elevation
- Limiting impact shock <3,000 G's
- Experienced-based design rules show how both electronics and mechanisms can survive these shock levels
- Additional mitigations being examined



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Mass and Data Budgets

Lander system entry mass:

ITEM	ESTIMATE
Payload	840 g
Telecom	100 g
Power	220 g
Entry	1450 g
Structure	1220 g
CD&H	60 g
Margin (27%)	1100 g
Total	5000 g

Data Return from Each Lander:

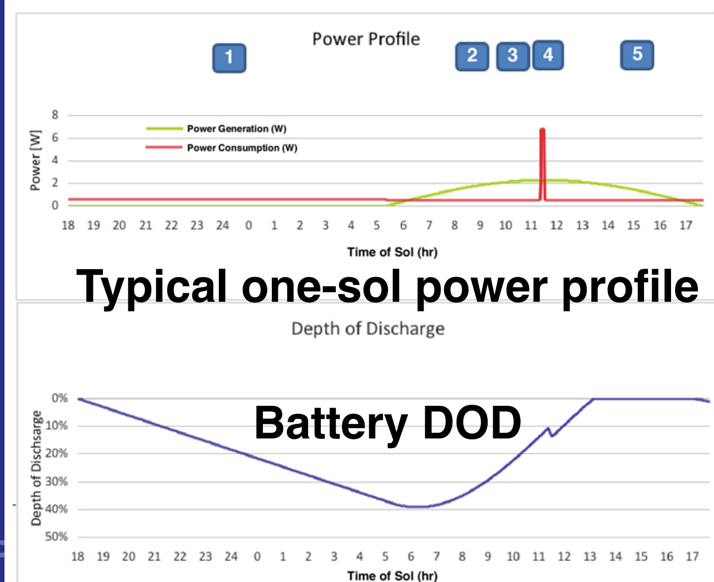
DATA BUDGET	
Data generation	Mbit / day
Seismometer	213
Cameras	17
Other science	2
Telemetry	1.4
Total	~230
Data uplink	480 sec @ 512 kbps
	1 pass / day

Power / Energy

- Telecom dominates power
- Existing power-efficient techniques result in ~1-2 W operations
- <200 mW is allocated to heating
- Nominal mode - payload operation, housekeeping/power management
- Imaging occurs daily
- Transmission of data occurs every sol
- Energy generation exceeds storage

Power Assumptions	
Cell type/number	LILT TJ x 32
Dust degration	25%
Latitude	35 deg S
Lander tilt angle	<15 deg

Mode Number	Power Mode	Day in Life Duration	Consumption (W)
1	Nominal	12:19:47	0.516
2	Nominal	6:00:00	0.516
3	Imaging	0:01:00	2.367
4	Transmit	0:08:00	6.820
5	Nominal	6:10:47	0.516



Operational mode	Safe-hold	Nominal	Imaging	Transmit
Payload		<0.1 W	1.3 W	<0.1 W
Housekeeping	0.4 W	0.4 W	0.5 W	5.8 W
Power overhead	0.1 W	0.1 W	0.3 W	0.9 W
Total	0.5 W	0.6 W	2.1 W	6.8 W

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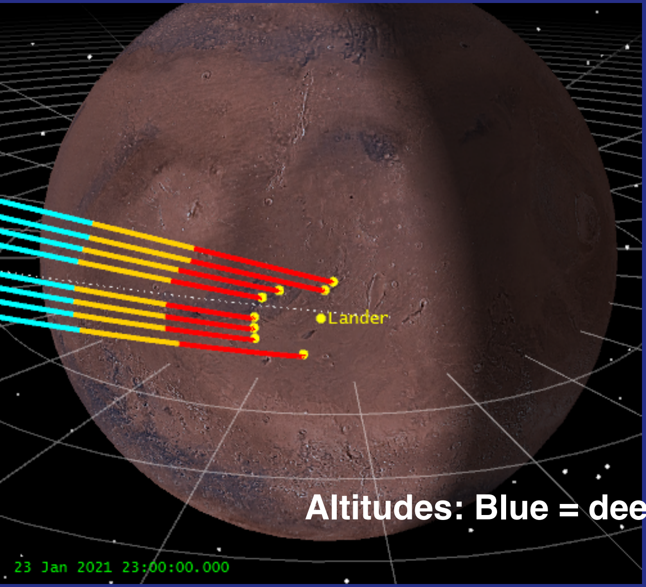
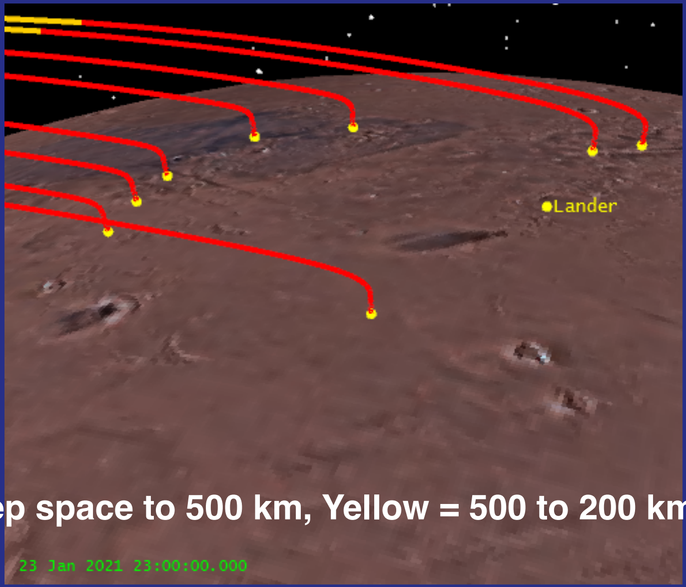
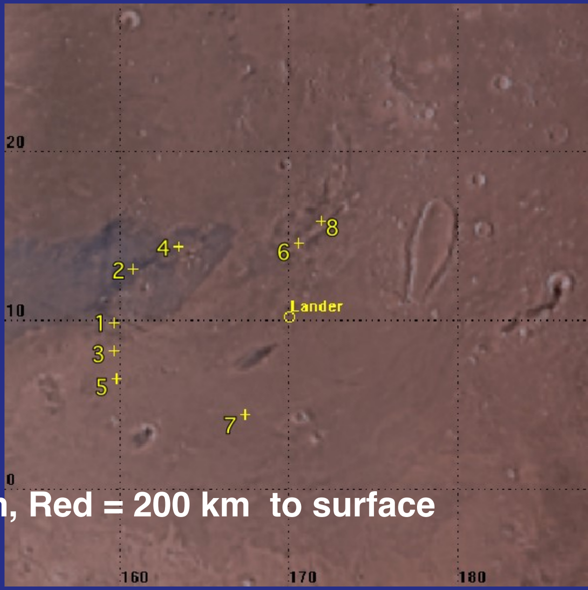
Deployment Description

- Vehicles released 10 or more days before landing
  - Avoids conflicts with primary 2020 vehicle during approach and landing
- Separation depends on deployer spring constant and time of release
  - Example shows 4 different spring constants (0.25, 0.5, 0.75, 1.0 m/sec)
  - Deployed 10 days out in 4 pairs, separated by 1 hr
  - Results in 600 km dispersion
- Assuming 2x spring constant & 20 day deployment, separation ~2400 km







Altitudes: Blue = deep space to 500 km, Yellow = 500 to 200 km, Red = 200 km to surface

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Risk Posture and Success Criteria

Risk	*Mitigation*
Mission assurance and part selection strategy	*Early planning. Mission success definiton and expectations. Rely on industry-accepted methodology*
EDL stability	*Leverage NASA ADEPT effort including Earth-based testing*
Landing impact shock and wind stability	*Integrated system approach to minimize sensitive parts. Early test verification*
Decoupling geophone from lander	*Utilize Leidos expertise to properly design sensor interface. Early test verification*

- Mission performance floor
  - One lander (out of n) landing and operating
- Science performance floor
  - Two landers to successfully land and operate
- One Mars year is needed to return full suite of observations
- For uncorrelated failures with 40% probability of occurrence
  - 4 landers provide a 98% probability of engineering success and 86% of meeting the science floor